Further notes on spiders from the Special Nature Reserve Zasavica (Serbia)

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Abstract. Zasavica is a wetland in western central Serbia with very little information on its spider fauna. During 2011 faunistic research was carried out; the material collected mostly using pitfall traps, but also sweep netting, beating and hand-collecting. A total of 3053 individuals were caught, and 107 species from 21 families were identified. Among these species, seven are first records for the Serbian fauna: *Holocnemus pluchei* (Scopoli, 1763), *Dactylopisthes digiticeps* (Simon, 1881), *Walckenaeria alticeps* (Denis, 1952), *Pachygnatha listeri* Sundevall 1830, *Liocranoeca striata* (Kulczyński, 1882), *Phrurolithus minimus* C. L. Koch, 1839 and *Tibellus maritimus* (Menge, 1875). Additionally, 59 species are new for the reserve. Beside a new species list for the reserve, some notes on these national records were made.

Keywords: deciduous forest, devastation, inundation forest, new records, Serbian fauna

Zusammenfassung. Ergänzungen zur Spinnenfauna des Zasavica-Naturschutzgebietes (Serbien). Zasavica ist ein Feuchtgebietskomplex im westlichen Mittelserbien, zum dem bisher nur wenige arachnologische Daten vorliegen. Im Jahr 2011 wurde eine faunistische Erhebung durchgeführt, wobei die Erfassung der Spinnen mittels Barberfallen, Keschern, Klopfen und Handaufsammlungen erfolgte. Insgesamt wurden 3053 Individuen, die sich auf 107 Arten aus 21 Familien verteilten, gesammelt. Sieben Arten wurden hierbei erstmals für Serbien nachgewiesen: *Holocnemus pluchei* (Scopoli, 1763), *Dactylopisthes digiticeps* (Simon, 1881), *Walckenaeria alticeps* (Denis, 1952), *Pachygnatha listeri* Sundevall 1830, *Liocranoeca striata* (Kulczyński, 1882), *Phrurolithus minimus* C. L. Koch, 1839 und *Tibellus maritimus* (Menge, 1875). 59 Arten sind Neufunde für Zasavica. Neben einer aktualisierten Artenliste wird die Ökologie und Verbreitung der Neufunde für Serbien näher beschrieben.

Research on spiders in Serbia has been neglected for years. From the first published data (Spasojević 1891) to the latest (Grbić et al. 2015), only 696 species were reported. As Serbia is a part of the Balkans, it could be marked as one of the most significant biodiversity regions in Europe (Savić 2008). The great number (379) of Balkans endemic spider species (Deltshev 2004), and Serbian endemic spiders (21) (Deltshev et al. 2003) support this hypothesis, but an understanding of its importance in support of more faunistic research is lacking. A rare positive example is the management of the Special Nature Reserve (SNR) Zasavica.

SNR Zasavica is a wetland in the western central Serbian region of Mačva. The majority of the protected zone includes the water surface of the Zasavica river and the Jovača, Prekopac and Batar canals. The second largest protected area is the Valjevac pasture with its mixture of semi-aquatic and hydrophilic vegetation and a dry pasture. Also under legal protection is the forest vegetation of the Reserve that contains various hydrophilic forests of European ash, poplar, willow and black alder (Obratov-Petković et al. 2007).

The first historical data reveal that only five spider species were recorded at the locality of Crna bara by Stoićević (1929): *Araneus diadematus* Clerck, 1757, *Araniella cucurbitina* (Clerck, 1757), *Dipoena braccata* (C. L. Koch, 1841), *Heliophanus cupreus* (Walckenaer, 1802) and *Xysticus lanio* C. L. Koch, 1835. Several years later, Drensky (1936) added *Argyroneta aquatica* (Clerck, 1757) to the list, found at the same locality (in Deltshev et al. 2003: 173), but after that no effort was invested in any kind of spider research in this area. Finally Grbić et al. (2011) created the first significant list of 104 spider species based on material collected during student scientific research camps that were organized only in August 2008, 2009 and 2010. In this study, five species were recorded for the first time in Serbia and, except for *D. braccata* and *X. lanio*, the historical records could be confirmed. This preliminary list of species formed a basis for future faunistic and ecological studies.

In 2011, further collection was performed at the localities of Valjevac and Turske livade, with an emphasis on the faunistic data and species composition in flooded and non-flooded forest areas. The project was a part of the Master's thesis of the first author. The results presented here are envisaged as additions to the faunal list and a short presentation of spider species new to Serbia. The second purpose of the manuscript is to draw attention to ongoing habitat devastation of the area that is out of control, and which could affect survival of the species.

Material and methods

The Turske livade locality (44° 57' 32", 19° 31' 37") is situated on the left side of the Zasavica river, at an altitude of 78–80 m. It consists of small forest fragments and arable land (Obratov-Petković et al. 2007). About 80% of these forests are private property (Stanković pers. comm.). Wood harvesting happens often, with no supervision, so human influence is very intensive on these forest habitats. For the purpose of this research, two non-flooded forests (coded as non-flooded forests 1 and 2) and one flooded forest were chosen. Non-flooded forests 1 and 2 are deciduous forest fragments with dry vegetation, a thick duff layer and many bushes. The flooded forest has dense vegetation with lots of shade, and becomes flooded during spring. More details on the vegetation of the habitats are given in Tab. 1.

The Valjevac locality (44° 56' 10", 19° 31' 11") is also situated on the left side of the river and at the same altitude as the previous locality, and it consists of a large pasture, forest fragments and arable land. The pasture is property of the Reserve, while 80% of the woods and all arable land are private property (Stanković pers. comm.). On this locality, one non-flooded forest, one flooded forest, the riverside near the Visitors' Centre and a pasture site were chosen for fieldwork. The non-flooded forest has a dense canopy, which provides lots of

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Tab. 2: ff.

General information	Valjevac				Turske livade			Number
Habitat	Flood forest	Non-flood forest	Visitor's center riverside	pasture	Flood forest	Non-flood forest 1	Non-flood forest 2	of individuals
Diplostyla concolor (Wider, 1834) [x]	196/194	.	15/6	.	112/36	0/1	2/0	562
Erigone dentipalpis (Wider, 1834)	9/0	0/1	68/0	.	43/0	.	1/0	122
Linyphia triangularis (Clerck, 1757)	1/0	.	1/0	.	2/0	2/0	0/2	8
Microlinyphia pusilla (Sundevall, 1830)	.	.	.	1/0	.	.	.	1
Neriene clathrata (Sundevall, 1830)	0/9	.	.	.	.	.	.	9
Oedothorax apicatus (Blackwall, 1850) [x]	.	.	50/68	.	.	.	9/19	146
Pelecopsis radicicola (L. Koch, 1872) [x]	.	.	.	.	3/2	.	.	5
Prinerigone vagans (Audouin, 1826)	.	.	2/0	.	.	.	.	2
Walckenaeria alticeps (Denis, 1952) * [x]	.	.	.	.	1/0	.	.	1
Walckenaeria furcillata (Menge, 1869) [x]	.	.	.	.	2/0	11/6	8/11	38
Walckenaeria mitrata (Menge, 1868) [x]	.	1/0	.	.	.	.	.	1
Tetragnathidae								
Pachygnatha clercki Sundevall, 1823 [x]	1/0	.	5/0	.	2/0	.	1/0	9
Pachygnatha degeeri Sundevall, 1830	5/3	.	4/4	.	9/3	.	1/0	29
Pachygnatha listeri Sundevall, 1830 * [x]	1/0	.	0/4	.	1/2	.	.	8
Tetragnatha extensa (Linnaeus, 1758)	.	.	3/1	.	.	.	.	4
Tetragnatha montana Simon, 1874	.	1/0	.	.	2/0	.	.	3
Tetragnatha nigrita Lendl, 1886 [x]	.	.	.	1/0	.	.	.	1
Tetragnatha pinicola L. Koch, 1870 [x]	.	.	.	0/1	.	.	.	1
Araneidae								
Araneus diadematus Clerck, 1757	.	.	.	.	.	0/1	.	1
Araneus quadratus Clerck, 1757	.	.	.	1/0	.	.	.	1
Hypsosinga pygmaea (Sundevall, 1831)	.	.	.	0/2	.	.	.	2
Larinioides patagiatus (Clerck, 1757)	.	.	.	3/3	.	.	.	6
Mangora acalypha (Walckenaer, 1802)	.	.	.	0/1	.	.	.	1
Singa hamata (Clerck, 1757) [x]	.	.	.	0/1	.	.	.	1
Lycosidae								
Alopecosa cf. *pinetorum* (Thorell, 1856) [x]	.	.	1/0	.	.	.	.	1
Arctosa leopardus (Sundevall, 1833)	0/1	.	147/44	1/0	4/3	.	2/3	205
Pardosa agrestis (Westring, 1861)	3/6	.	7/0	.	0/1	.	.	17
Pardosa alacris (C.L. Koch, 1833) [x]	.	0/1	.	.	7/4	0/2	9/62	85
Pardosa amentata (Clerck, 1757)	0/12	.	8/13	0/1	3/6	0/2	1/1	47
Pardosa hortensis (Thorell, 1872)	0/2	.	3/5	.	.	0/1	0/2	13
Pardosa lugubris (s.lat.) (Walckenaer, 1802)	0/1	.	.	.	0/7	0/5	0/9	22
Pardosa cf. *mixta* (Kulczyński, 1887) [x]	0/2	.	.	.	.	.	.	2
Pardosa monticola (Clerck, 1757)	1/6	.	0/2	.	0/1	.	.	10
Pardosa prativaga L. Koch, 1870	0/2	.	8/1	.	6/1	.	.	18
Pardosa proxima (C.L. Koch, 1847)	1/7	.	28/10	0/4	.	.	2/0	52
Pardosa vittata (Keyserling, 1863) [x]	0/2	.	.	.	.	.	.	2
Pirata piraticus (Clerck, 1757)	1/1	.	4/9	.	1/0	.	.	16
Pirata cf. *tenuitarsis* Simon, 1876 [x]	.	.	13/0	.	.	.	.	13
Piratula hygrophila (Thorell, 1872)	5/20	1/12	5/2	.	11/4	.	1/0	61
Piratula latitans (Blackwall, 1841)	0/8	.	128/27	.	36/8	.	0/1	208
Trochosa hispanica Simon, 1870 [x]	2/0	1/2	.	.	8/3	.	.	16
Trochosa ruricola (De Geer, 1778) [x]	.	.	1/0	.	.	.	.	1
Xerolycosa miniata (C.L. Koch, 1834) [x]	0/1	.	.	.	.	.	.	1
Pisauridae								
Dolomedes fimbriatus (Clerck, 1757)	1/0	.	.	.	.	.	.	1
Dolomedes plantarius (Clerck, 1757)	.	.	0/1	.	.	.	.	1
Pisaura mirabilis (Clerck, 1757)	0/1	.	.	.	1/2	.	1/1	6
Miturgidae								
Zora spinimana (Sundevall, 1833) [x]	.	1/3	.	.	.	.	.	4
Agelenidae								
Agelena labyrinthica (Clerck, 1757)	.	.	.	.	4/0	.	.	4
Histopona torpida (C.L. Koch, 1837)	.	6/1	.	.	7/0	109/20	96/28	267

Tab. 2. ff.

General information	Valjevac				Turske livade			Number of individuals
Habitat	Flood forest	Non-flood forest	Visitor's center riverside	pasture	Flood forest	Non-flood forest 1	Non-flood forest 2	
Tegenaria campestris (C.L. Koch, 1834) [x]	.	2/0	.	.	.	.	.	2
Tegenaria silvestris (L. Koch, 1872) [x]	.	.	.	.	.	0/1	.	1
Urocoras longispinus (Kulczyński, 1897) [x]	.	70/11	.	.	67/11	129/8	4/0	300
Dictynidae								
Dictyna uncinata Thorell, 1856	.	.	.	.	1/0	.	.	1
Liocranidae								
Agroeca cuprea Menge, 1873 [x]	0/1	.	.	.	.	4/0	0/4	9
Liocranoeca striata (Kulczyński, 1882) * [x]	0/7	0/6	.	.	1/0	2/0	.	16
Clubionidae								
Clubiona brevipes Blackwall, 1841 [x]	.	.	.	0/1	.	.	.	1
Clubiona comta C.L. Koch, 1839 [x]	.	.	.	.	.	.	1/0	1
Clubiona lutescens Westring, 1851	1/4	.	.	.	2/2	.	.	9
Clubiona pallidula (Clerck, 1757)	.	.	.	.	1/0	.	1/3	5
Clubiona phragmitis C.L. Koch, 1843 [x]	.	.	1/0	.	.	.	.	1
Clubiona terrestris Westring, 1851	.	0/1	.	.	.	2/2	.	5
Corinnidae								
Cetonana laticeps (Canestrini, 1868) [x]	.	.	.	.	.	2/0	.	2
Phrurolithidae								
Phrurolithus festivus (C.L. Koch, 1835) [x]	17/33	.	6/1	.	91/10	.	.	158
Phrurolithus minimus C.L. Koch, 1839 * [x]	5/0	.	.	.	.	.	.	5
Gnaphosidae								
Drassyllus lutetianus (L. Koch, 1866) [x]	1/0	.	2/0	.	0/1	.	.	4
Drassyllus pusillus (C.L. Koch, 1833) [x]	0/1	.	.	.	.	.	.	1
Drassyllus villicus (Thorell, 1875) [x]	0/3	.	.	.	4/0	.	13/7	27
Haplodrassus silvestris (Blackwall, 1833) [x]	.	.	.	.	.	.	5/0	5
Micaria pulicaria (Sundevall, 1831) [x]	.	.	.	.	1/0	.	.	1
Trachyzelotes pedestris (C.L. Koch, 1837) [x]	1/6	.	.	.	5/1	.	3/2	18
Zelotes apricorum (L. Koch, 1876) [x]	1/0	.	.	.	2/5	.	1/1	10
Zelotes latreillei (Simon, 1878) [x]	2/0	.	0/1	.	2/1	.	.	6
Philodromidae								
Tibellus maritimus (Menge, 1875) * [x]	.	.	0/1	.	.	.	.	1
Thomisidae								
Cozyptila blackwalli (Simon, 1875) [x]	.	.	.	.	.	.	1/0	1
Ebrechtella tricuspidata (Fabricius, 1775)	.	.	.	5/0	.	.	.	5
Misumena vatia (Clerck, 1757)	.	.	.	7/0	.	.	.	7
Ozyptila praticola (C.L. Koch, 1837)	42/12	0/4	.	.	21/2	74/0	50/0	205
Ozyptila simplex (O. P.-Cambridge, 1862) [x]	0/2	.	.	.	.	.	.	2
Synema globosum (Fabricius, 1775)	.	.	.	1/0	.	.	.	1
Tmarus piger (Walckenaer, 1802)	.	1/0	.	.	0/1	.	.	2
Xysticus kochi Thorell, 1872	2/0	.	0/1	.	.	.	.	3
Xysticus luctator (L. Koch, 1870)	.	.	.	.	22/0	9/0	5/0	36
Salticidae								
Ballus chalybeius (Walckenaer, 1802) [x]	.	.	.	.	.	9/2	1/0	3
Evarcha falcata (Clerck, 1757)	.	.	.	.	.	.	1/0	1
Evarcha laetabunda (C.L. Koch, 1846) [x]	.	.	.	1/0	.	.	.	1
Heliophanus flavipes (Hahn, 1832)	1/0	.	.	.	.	.	.	1
Marpissa muscosa (Clerck, 1757)	0/1	1/0	.	.	.	.	.	2
Marpissa radiata (Grube, 1859) [x]	.	1/0	.	.	.	.	.	1
Mendoza canestrinii (Ninni, 1868)	.	.	0/1	.	.	.	.	1
Myrmarachne formicaria (De Geer, 1778) [x]	.	0/1	.	.	.	.	.	1
Neon reticulatus (Blackwall, 1853) [x]	0/1	.	.	.	.	0/1	.	2
Pseudeuophrys obsoleta (Simon, 1868) [x]	.	.	2/0	.	.	.	.	2
Pseudicius encarpatus (Walckenaer, 1802)	.	.	1/0	.	.	.	.	1
Salticus zebraneus (C.L. Koch, 1837) [x]	.	.	0/1	.	.	.	.	1
Sitticus floricola (C.L. Koch, 1837) [x]	.	.	1/0	0/1	.	.	.	2

Analysing the result presented in Tab. 2, some clear differences between the habitats are obvious but will not be discussed in detail. In the forest habitats, the highest number of species was found in the flooded forest at the Valjevac locality, where 46 spider species were recorded, while the smallest number of species was in the non-flooded forest at the same locality (19 species) (Tab. 2). At the second research locality of Turske livade, even lower numbers of species were recorded in all habitats compared to the Valjevac flooded forest. No species were common for all the habitats (Tab.2).

Discussion

First records for the Serbian spider fauna

Holocnemus pluchei

Records. 1♀, 16.09.2011; Valjevac – flooded forest

Note. The original distribution for this species is Africa, the Mediterranean region and the Middle East (Huber 2011), but today this species is spread over Western, Central and Eastern Europe (World Spider Catalog 2014). According to Nentwig et al. (2014), it was previously recorded in the countries surrounding Serbia, so this species was expected to be found here as well. The related species, *H. caudatus* (Dufour, 1820) and *H. hispanicus* Wiehle, 1933, have a very low probability of appearance in our region, since they are common in Spain, Portugal and Sicily (World Spider Catalog 2014).

Dactylopisthes digiticeps

Records. 12♂♂ 10.06.2011; 32♂♂ 30.06.2011; 4♂♂ 03.08.2011. Valjevac – a riverside Visitors' Centre; 2♂♂ 30.06.2011. Turske livade - Non-flood forest 2

Note. This species was first described by Simon (1881) from a male specimen, while the female was described 115 years later (Weiss & Schneider 1996). As a typical habitat of this spider, Weiss & Schneider (1996) suggested wetlands and vegetation near water. In their research it was found at some localities near the Danube River together with other wetland species. According to the World Spider Catalog (2014), the global distribution of this species covers an area from Europe to Israel, Iran and Afghanistan, but in Europe this species was recorded only in some countries (Nentwig et al. 2014): France, Austria, Romania, Ukraine, Greece. Because of its scattered distribution, this record represents an important element of the Serbian fauna and we feel obliged to make a note about how its future could be affected here. The Visitor's centre at the riverside where this species if found is under a great pressure from tourism (both legal and illegal) and uncontrolled seasonal cane harvesting. According to what we know from the field, we think that there is a high possibility of habitat loss in the near future so these new records would be lost and the species could become lost in Serbia too. For prevention we suggest that this species should be included in the list of protected species in Serbia. Only if SNR Zasavica has a legal obligation to pay more attention to this species and its habitat will everything be maintained.

Walckenaeria alticeps

Records. 1♂ 12.10.2011; Turske livade – flood forest

Note. Closely related and often confused with *W. antica*. Males of these species are morphologically very similar (Kronestedt 1980, Palmgren 1982), both in the cephalic part and in the configuration of the palps. Females are less problematic (Kronestedt 1980), but we didn't have any among our material. The sibling species *W. antica* was recorded in Serbia (in Deltshev et al. 2003:132) in 1929 and 1936 before *W. alticeps* (Denis, 1952) was even described and since the old material is not available, it remains uncertain what we had in Serbia so far. If we accept that we already had *W. antica*, looking at the global distribution area of the *W. alticeps*, which is from Europe to Central Asia (World Spider Catalog 2014), this record in Serbia is not surprising (Nentwig et al. 2014).

Pachygnatha listeri

Records. 1♂/1♀ 10.06.2011. Turske livade – flood forest; 3♀♀ 30.06.2011. Valjevac – a riverside Visitors' center; 1♂ 3.08.2011 Valjevac – flood forest; 1♀ 3.08.2011 Valjevac – a riverside Visitors' center; 1♀ 15.09.2011.Turske livade – flood forest

Note. In general appearance similar to the *P. clercki* and *P. terilis* but close study of genital details allows it to be distinguished very well (Nentwig et al. 2014). It has a Palaearctic distribution (World Spider Catalog 2014) and it is widely distributed in Europe. The species was not found in most countries of the Balkan Peninsula, except Bulgaria and Romania (Nentwig et al. 2014). Based on such a wide distribution, this species was expected to be found in our country as well. Our discovery of this species in the flooded forests of both localities also corresponds to literature data (Roberts 1995, Krumpálová 1997, Hänggi et al.1995).

Liocranoeca striata

Records. 1♂ 10.06.2011. Turske livade – flood-forest; 2♂♂ 30.06.2011. Turske livade – non-flood foorest 1; 5♀♀ 03.08.2011. Valjevac – flood forest; 5♀♀ 03.08.2011. Valjevac – non-flood forest; 2♀♀ 16.09.2011. Valjevac – flood forest; 1♀ 16.09.2011. Valjevac – non-flood forest

Note. Not so hard to determine although several synonyms make a literature search more difficult. According to the World Spider Catalog (2014), this species is distributed across Europe and Russia. Widespread but rare in northern Europe (Roberts 1995), it was already recorded in some surrounding countries (Hungary, Macedonia, Bulgaria, Romania) (Nentwig et al. 2014), so it could be expected in Serbia too. This species prefers wet habitats, especially deciduous forests on wetlands and alluvial plains (Roberts 1995, Buchholz 2009, Nentwig et al. 2014). According Hänggi et al. (1995) it is associated exclusively with the "layer 1" which means that it prefers soil and litter.

Phrurolithus minimus

Records. 5♂♂ 03.08.2011; Valjevac – flood forest

Note. The global distribution of this species is Palearctic (World Spider Catalog 2014), and it is present all over Europe, but not in most parts of the Balkan Peninsula (Nentwig et al. 2014). Since it was recorded in Hungary and Romania (Nentwig et al. 2014), it was expected to be found in Serbia too. According to Nentwig et al. (2014) and Hänggi et al. (1995), this species prefers dry meadows, steppes, rocky slopes and open forests, but could also be found on peat area (Rėlys & Dapkus 2002) or at the edges of forests and on oligotrophic grasslands (Hänggi et al. 1995). It is connected to the litter (Hänggi et al. 1995) where we also found it in flooded wood of willow, ash and European alder.

Tibellus maritimus

Records. 1♂ 10.06.2011; Valjevac – a riverside Visitors' center

Note. Among the European philodromid species *Tibellus* sp. can easily be distinguished by the slender body and legs. Differences between the species in the genera are more or less solid, so determination is not so complicated (Efimik 1999). This species has a Holarctic distribution (World Spider Catalog 2014), and with records from almost all European countries (Nentwig et al. 2014) it was also expected in Serbia. Usually *T. maritimus* can be found both on humid and dry but also sunny places (Nentwig et al. 2014, Cera et al. 2010), and the riverside Visitor's centre in our study is just like that. But like in the case of *Dactylopisthes digiticeps* described earlier, the future of the species is uncertain since the riverside is under constant threat. If we add the fact that this species completely disappeared from Poland after the drying up of flooded areas (Kajak 1993), we have to suggest that this species should also be included in the list of protected species in Serbia to prevent the possibility of a loss scenario.

Species of special interest

Tetragnatha pinicola

Records. 1♀ 19.05.2011. Valjevac - pasture

Note. Very similar to *T. extensa* (see Russell-Smith 2011). Although they normally differ markedly in size, occasionally *T. pinicola* may superficially resemble young *T. extensa* and stayed unnoticed. This specimen was found by chance and caught by sweep netting. Apparently it has a Palaearctic distribution (World Spider Catalog 2014), but it is also considered very rare in Northern Europe (Roberts 1995). In Serbia this species was last recorded in 1985 at the Sokolica locality on the Veliki Jastrebac Mountain (Deltshev et al. 2003). Since then no recent records were made and its current status in the country cannot be determined, therefore its rediscovery in the protected area of the SNR Zasavica could be highly relevant for the species and for the future habitat protection plans of the Reserve.

Trochosa hispanica

Records. 3♂♂/2♀♀ 03.08.2011. Valjevac – non-flood forest; 2♂♂ 03.08.2011. Valjevac – flood forest; 8♂♂/3♀♀ 12.10.2011. Turske livade – flood-forest

Note. According to literature data *T. hispanica* was very recently found in Serbia by Ćurčić et al. (2007) in Čačak. But as Hepner & Milasowszky (2006) noted, many misidentifications of *Trochosa* females occur in museum and private collections. Considering also that no specimens from Serbia have been included in their revision or rechecked yet, there is a possibility that *T. hispanica* could be more widely present in Serbia, not only at the two recently discovered localities. Unfortunately, most of the old collection records are lost or could not be re-checked, so the current status and distribution of the *T. hispanica* as a Mediterranean species (Nentwig et al. 2014) in Serbia still needs to be confirmed.

Conclusions

Based on our first impressions, the number of new records in Serbia appears to be high for the small sampled area, but most of the species were already known in the surrounding countries (Nentwig et al. 2014), thus their presence at Zasavica was not unexpected. This research increased the total number of species in Serbia to 703, although this is only a fraction of what would be expected for this region. More important is that this is a one more step towards a future comprehensive species list. Spider research in the Special Nature Reserve Zasavica is also far from complete. Together with the current results, a total number rose to 163 species, but we could roughly estimate that at least the same number still awaits detection. In future studies, it should be investigated if there is any connection between species compositions and human devastation in the area, since unsupervised harvesting is still taking place.

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Sažetak

Zasavica predstavlja jedno od vlažnih staništa centralne Srbije sa veoma malo podataka o fauni paukova. Zbog toga je 2011 godine sprovedeno faunističko istraživanje tokom kojeg je material najvećim delom sakupljan klopkama, ali i ručno, zatim košenjem i trešenjem. Ukupno je sakupljeno 3053 jedinki i utvrdjeno je 107 vrsta iz 21 familije. Medju svim tim vrstama, sedam predstavlja prve nalaze za faunu Srbije: *Holocnemus pluchei* (Scopoli, 1763), *Dactylopisthes digiticeps* (Simon, 1881), *Walckenaeria alticeps* (Denis, 1952), *Pachygnatha listeri* Sundevall 1830, *Liocranoeca striata* (Kulczyński, 1882), *Phrurolithus minimus* C. L. Koch, 1839 and *Tibellus maritimus* (Menge, 1875), dok 59 vrsta predstavlja prve nalaze za rezervat. Pored nove liste vrsta, u radu su malo detaljnije komentarisani i novi nacionalni nalazi.

Impact of prescribed burning on a heathland inhabiting spider community

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Abstract. Heathlands can provide refuge for many stenotopic and endangered arthropods, if habitat management practices are applied. A management measure that is rarely being used today, but which has the potential to support diversity of arthropod communities, is prescribed burning. In this study we investigated the effects of prescribed burning on spider assemblages on a burned site with *Calluna vulgaris* in the nature reserve Lueneburg Heath, northwest Germany. We used pitfall trapping with a sampling design of 39 traps over a period of one year and 17 sampling intervals on a burned and a control site. We compared overall species richness, activity abundance patterns and community composition of the two sites, with a particular focus on stenotopic and endangered species. We collected 5116 adult spiders and 99 species altogether in a relatively small sampling area. This number of species represents nearly one third of the regional species pool of heathland spider species. Twelve species occurred exclusively on the burned site in contrast to 28 species exclusively found on the unburned site. Although we found more than twice as many spider individuals and higher mean species richness on the control site than on the burned site, the species richness of red-listed spiders was higher on the burned site. Especially the fact that we found 24 endangered species on the burned site and only 20 on the control site indicates that the applied measure of prescribed burning can foster certain endangered spider species and contribute to preserving the overall biodiversity of heathland ecosystems.

Keywords: endangered species, habitat management, Nature Reserve Lueneburg Heath (Lüneburger Heide), pitfall trapping, species richness

Zusammenfassung. Auswirkungen von kontrolliertem Brennen auf eine Heide bewohnende Spinnengesellschaft. Heidelandschaften können als Refugium für viele stenotope und gefährdete Arthropodenarten fungieren, wenn ein bestimmtes Heidemanagement angewandt wird. Eine Managementmaßnahme, die zwar heute selten praktiziert wird, obwohl sie sich positiv auf die Diversität von Arthropodengesellschaften auswirkt, ist kontrolliertes Brennen. In dieser Arbeit untersuchen wir die Auswirkungen von kontrolliertem Brennen auf eine Spinnenzönose einer mit *Calluna vulgaris* bestandenen Brandfläche im Naturschutzgebiet Lüneburger Heide in Nordwestdeutschland. Die Spinnen wurden in 39 Bodenfallen über einen Zeitraum von einem Jahr mit 17 Fallenleerungen auf der gebrannten und einer Kontrollfläche gefangen. Wir vergleichen die Artenvielfalt, die Individuenhäufigkeit und die Zusammensetzung der Spinnengemeinschaft der beiden Flächen miteinander. Wir fingen 5116 adulte Spinnenindividuen mit 99 Arten auf einer verhältnismäßig kleinen Probefläche. Diese Anzahl der Spinnenarten stellt fast ein Drittel des regionalen Artenpools der Heidespinnenarten dar. Wir fanden zwölf Arten ausschließlich auf der gebrannten und 28 ausschließlich auf der ungebrannten Fläche. Obwohl die durchschnittliche Artenzahl größer und die Gesamtzahl der Individuen fast doppelt so hoch auf der Kontrollfläche war, war dennoch die Artenvielfalt der gefährdeten Arten auf der gebrannten Fläche höher als auf der ungebrannten. Allein die Tatsache, dass wir insgesamt 24 gefährdete Arten auf der gebrannten Fläche und nur 20 gefährdete Arten auf der Kontrollfläche fanden, weist darauf hin, dass die angewandte Maßnahme des kontrollierten Brennens bestimmte Spinnenarten fördern und zur Erhaltung der Biodiversität der Heideökosysteme beitragen kann.

While the vascular plant community of heathlands seems to be rather poor in species numbers, the arthropod fauna of these habitats is rich in species, especially in stenotopic ones (e.g. Schikora & Fründ 1997, Finch 2013). The composition of the faunal communities and especially the occurrence of stenotopic species of heathlands seem to be strongly affected by the different habitat management practices that are applied (esp. choppering, sod-cutting, grazing, mowing, and burning) (see e.g. Gardner 1991). During historical times, north-west German heathlands were used by a diverse mixture of historical forms of land use. A consequence of these land use practices was that the development cycle of the dominant vascular plant species, the common heather (*Calluna vulgaris*) started consistently from seedlings or (re-)sproutings. The senescent stage with tall, strongly woody and sparsely foliated heather individuals was very rare during former centuries (Gimingham 1972, Keienburg & Prüter 2004). In contrast, nowadays this stage is widely distributed in heathlands due to abandoned land use, and species that were formerly promoted by habitat conditions of early successional heather stages might be detrimentally affected by this development in heather management.

Prescribed burning, a historically frequently used habitat measure by shepherds is only rarely used nowadays to rejuvenate heather. The effects of this management practice on animals, especially on protected or heathland typical species, is controversially discussed. For reptiles, the benefits of prescribed burning are not well understood (Jofré & Reading 2012) and prescribed burning is considered to be least harmful during winter when most of the reptiles are hidden in the ground where they are protected against the fire. For arthropods, however, benefits from prescribed burning have been demonstrated in several cases (e.g. some stenotopic ground beetles appear more abundantly about 2 or 3 years after prescribed burning; den Boer & van Dijk 1994). However, there are only a few studies on the effect of prescribed burning on the spider community of heathlands which are remarkably rich in species (Kaiser 2013). Moreover some endangered spider species are known to occur preferentially on burned sites (Schmidt & Melber 2004) and might even depend on this habitat management practice. Many spider species are known to react sensitively to habitat structures (Uetz 1990) which are also altered by prescribed burning. In contrast ground dwelling spider species are not very much affected by fire in general (prescribed and wild fire) as the temperatures at depths of 4 cm depth are not changed more than 2 °C and even at 1–2 cm depth do not exceed 40–50 °C for a very short timeframe depending on the season and the local soil conditions (Gerland 2004). In combination with other management practices, prescribed burning might thus create a heterogeneous complex of different habitats and habitat structures that could promote not only endangered species, but overall biodiversity as well.

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Fig. 1: The study area showing the unburned (left) and the burned site (right) one and a half years after burning during the sampling period (March 2008)

The advantages to apply different habitat management practices are also understood by political authorities and local conservation associations. Despite the high costs of some measures as e.g. choppering, some institutions are willing to manage heathlands also with prescribed burning (Lütkepohl 1993) provided that endangered animals of heathlands benefit from this specific heathland practice. Reliable data are scarce, however, and more research on the effects of prescribed burning on arthropods is needed.

Here, we studied the spider fauna of a heathland site one year after prescribed burning and compare spider richness, abundance and assemblage composition patterns to an unburned control site. The main questions of our study were: (1) To what extent does prescribed heathland burning affect the abundance and distribution of spider species, in particular of endangered species? (2) Is there any evidence that individual species benefit from prescribed burning, and is it possible to infer how such species reach the burned study site? (3) Can prescribed burning be considered an appropriate measure to foster endangered spider species and the biodiversity of the spider community in lowland heathlands?

Material and methods

Study area. The study site is situated in the nature reserve Lüneburger Heide (Lueneburg Heath) about 8 km east of Schneverdingen, Lower Saxony, Germany. The nature reserve includes the largest heathlands of north-west Germany, covering approximately 5000 ha, and is protected by the European Habitats and Species Directive as a Natura 2000 site. Its climate is humid, suboceanic with mean annual precipitation of 811 mm and a mean annual temperature of 8.4 °C (Niemeyer et al. 2007). Soils are predominantly nutrient-poor podzols with low pH values of 3.2 - 3.6.

The study area itself (53°15'N; 09°58'E; 105 m a.s.l., Niemeyer et al 2006) (Fig. 1) is slightly sloping to the south and consisted of two parts: 1. The unburned site with approximately ten year old heather of about 50 cm height; 2. the burned site covering an oblong of 220 x 200 m surrounded by the unburned area. Prescribed burning took place in autumn 2006, one year before we started to carry out our study.

Sampling design. We installed a total of 39 pitfall traps, filled with a mixture of 50 % ethanol, 20 % glycerol and 30 % water (Renner 1982), along a transect with 20 pitfalls across the burned site and 19 pitfalls along the edges in the unburned heather, 10 m apart from the burned site. Pitfall trapping represents the most efficient method for capturing ground-dwelling spiders, especially for locomotory active spider species (Curtis 1980, Southwood & Henderson 2000).

The pitfall traps were set up on 14th August and the catching period was extended over the length of twelve months beginning on 28th August 2007 and ending on 14th August 2008. The capturing periods in August 2007 and August 2008 each lasted only half a month. The traps were emptied once per month during the winter and fortnightly during the summer, resulting in a total of 17 sampling intervals.

Only adult spiders were identified using the online spider guide of Nentwig et al. (2014). Taxonomy follows the World Spider Catalog (2015).

Habitat characteristics. Vegetation data was gathered within a circle of 100 cm diameter around each trap. We visually estimated the percentage cover of *Calluna vulgaris*, grasses, lichens, mosses, trees, and bare soil in three layers: a) 0–5 cm, b) 5–50 cm, c) over 50 cm. Additionally for measuring the pH-value we took 20 samples of approximately 0.5 L with a spade every three months from randomly chosen plots in the burned (n =1 0) and unburned site (n = 10).

Statistical analysis. Differences between the burned and unburned site were analysed with t-tests. Homogeneity of variances was checked prior to the analyses. Differences in the composition of the spider assemblages of the burned and unburned plots were analyzed using non-metric multidimensional scaling (NMDS; vegan package in R; Oksanen et al. 2013). The NMDS was based on abundance-weighted dissimilarities in spider assemblages among the 39 pitfall traps, using the Morisita-Horn index on square-root transformed abundance data. A stable solution with k = 2 dimensions was computed from multiple random starting configurations. Results were centred and principal components rotation was used to obtain maximum variance of points on the first dimension. The relationship with environmental factors was assessed by fitting habitat parameters (after standardization) to the ordination plot on the basis of a regression analysis with the NMDS axes scores. Significance of the correlations

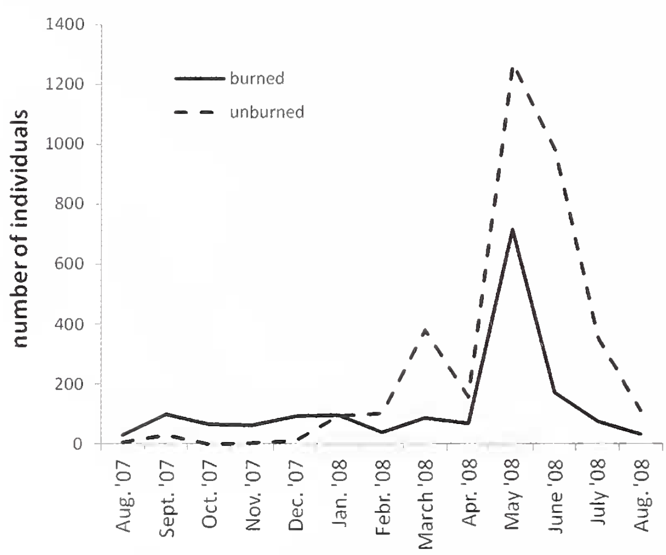

Fig. 2: Seasonal dynamics of spider activity abundance in the burned and unburned sites